# Interactions of mercury and selenium in bioaccumulation and toxicity in San Francisco Bay plankton

**Nick Fisher**

# Final Selection Panel Review

## Proposal Title

#0027: Interactions of mercury and selenium in bioaccumulation and toxicity in San Francisco Bay plankton

## Funding:

**Fund with future funds**
Amount: **$476,226**

**The final Selection Panel agreed with its original recommendation on the merits of this proposal. Due to the recent reduction in funds available for the Science Program's 2004 PSP, the Selection Panel has been forced to place this proposal in the Fund with Future Funds category. This decision was based solely on the current programmatic priorities of CALFED and the current level of available funds for purposes of supporting research efforts of this nature. This decision was not a reflection of the technical merit of this proposal.**

## Public Comments

No public comments were received for this proposal.

# Initial Selection Panel Review

## Proposal Title

#0027: Interactions of mercury and selenium in bioaccumulation and toxicity in San Francisco Bay plankton

## Funding:

**Fund**
Amount: **$476,226**

## Initial Selection Panel (Primary) Review

### Topic Areas

- Environmental Influences On Key Species And Ecosystems
- Relative Stresses On Key Fish Species

Please describe the relevance and strategic importance of this proposal in the context of this PSP. How does the proposal address the topic areas identified above? What are the broader CALFED Goals this proposal may meet that are not accounted for in these specific topic areas?

**The proposal relates to the possible effects (bioaccumulation and toxicity) of Hg and Se in combination on phytoplankton and zooplankton in the BD system, and therefore on the condition of higher trophic levels including key fish species within the system. Since both elements occur together in the system, the study is relevant and if the effects are large, the study could be of strategic importance.**

The budgets of proposals submitted in response to this PSP are larger, on average, than those submitted to CALFED in previous years. The Science Program is committed to getting as much science per dollar as is reasonably possible. With this commitment in mind, can the proposed budget be streamlined? If so, please recommend and clearly justify a new budget total in the space provided.

**Overall, this is a well written proposal by an appropriately**

**experienced, well-published research team led by Fisher. All reviewers seem impressed by the proposal and feel that the budget is reasonable. A three year study is proposed with most of the funds being used for personnel including Ph.D. level scientists and graduate students or assistants.**

## Evaluation Summary And Rating.

Provide a brief explanation of your summary rating and any additional comments you feel are pertinent.

**The key issue here is whether this study will yield data that will allow the investigator to determine if the stated null hypothesis is correct (i.e. that the bioaccumulation and toxicities of the Selenite and Hg(+2) [or Methylmercury] are unchanged when they are mixed, and that this result can be transferred to the BD system.) There are some confounding aspects of the resarch plan, one of which is that simultaneous measurement of Hg and Se uptake is not measured simultaneously because the bioaccumulation levels are being measured via gamma-emitting isotopes which would interfere. Will the measurements be so accurate and precise (as claimed) such that this will not be a problem? Perhaps. There is also the question of whether the use of selenite as the only Se species (rather than also doing organic complexes, for example), or the neglect of possible suspended or settled sediments effects on these processes will compromise the results. One tends to have confidence in Fisher and to say, let's see how it goes (i.e. fund the study). But couldn't one also do some studies with stable isotopes (Se+Hg together) to at least verify the gamma ray method; or do some experiments to determine if more realistic environmetal conditions yield the same results? Almost certainly they will be back for more funds in years to come to investigate in situ Delta conditions after this study, so I would vote for a bit more money and an expanded project rather than accept this study as it is. If that is not feasible, then I guess I would have to vote "Fund" with some reservations but with respect for the other reveiwers.**

# Selection Panel (Discussion) Review

fund this amount: $**476,226**
note:
**fund**

**This proposal by a competent research team, looks at effects of combined exposure to mercury and selenium, using gamma−emitting radioisotopes to study accumulation in San Francisco Bay plankton, the first study to elucidate an interactive effect at this trophic level.**

**The Panel felt the methodology was a strong approach to a problematic measurement issue, but was concerned with the potential technical flaw of overlapping gamma emissions of mercury and selenium isotopes that makes it difficult to measure the two contaminants simultaneously. It is substantially less expensive than other proposed selenium work, although the topic is substantially different. The research team is very strong, and the science has a good chance of strong results.**

**This work including interactive mercury/selenium toxicity and bioaccumulation, would fit into the CALFED Mercury Strategy as an elucidation of basic processes of mercury moving through the food web. Without this information about lower trophic levels, the system cannot be effectively modeled. However, it is not clear that this would be directly applicable to CALFED's most important management goals. Overall, The Panel was not thoroughly convinced that the payoff for CALFED agencies' management would be large. In addition, there are also other efforts to address these priorities.**

**Overall, The Panel recommend funding, but with strong reservations.**

**Panel Ranking: Fund with reservations**

# Technical Synthesis Panel Review

## Proposal Title

#0027: Interactions of mercury and selenium in bioaccumulation and toxicity in San Francisco Bay plankton

| Final Panel Rating |
| --- |
| **above average** |

## Technical Synthesis Panel (Primary) Review

### TSP Primary Reviewer's Evaluation Summary And Rating:

**The PIs present a compelling case for better understanding the initial stages of bioaccumulation of selenium and mercury in plankton. Many studies have shown that both metals bioaccumulate through higher trophic levels. In some cases, Se has been implicated as being antagonistic to MeHg bioaccumulation. Since both metals presumably accumulate through trophic transfer, it is important to understand the process that represents the greatest step in biomagnification – uptake from the dissolved phase to plankton. The investigators have ample experience in culturing phytoplankton and zooplankton and performing uptake studies. Their ability to work at environmentally relevant concentrations is strengthened by the fact that they intend to use gamma–emitting radioisotopes in their study. They have used this approach successfully in the past and intend to apply it to cultures of plankton isolated from their current studies in the Bay–Delta. The research team is well–qualified to undertake this study. Reviewers had concerns that it was not clear what work had been already completed for Hg and MeHg in the current CALFED study. Furthermore, there is little discussion of how the results of the laboratory experiments will be "ground–truthed" to the sites of interest. While the investigators have cultured phytoplankton from previous work**

**in the Bay–Delta, it appeared that the further aspects of the lab studies were decoupled from any further field comparisons. How do natural ligands in the study sites compare to those of the laboratory incubations? There is no mention of application of geochemical speciation models for both lab studies and field applicability. Will spikes be pre–equilibrated with natural water (and ligands)? These omissions detract from a well–designed laboratory study and justify a rating less than "superior".**

## Additional Comments:

**The PIs present a compelling case for better understanding the initial stages of bioaccumulation of selenium and mercury in plankton. Many studies have shown that both metals bioaccumulate through higher trophic levels. In some cases, Se has been implicated as being antagonistic to MeHg bioaccumulation. Since both metals presumably accumulate through trophic transfer, it is important to understand the process that represents the greatest step in biomagnification – uptake from the dissolved phase to plankton. The investigators have ample experience in culturing phytoplankton and zooplankton and performing uptake studies. Their ability to work at environmentally relevant concentrations is strengthened by the fact that they intend to use gamma–emitting radioisotopes in their study. They have used this approach successfully in the past and intend to apply it to cultures of plankton isolated from their current studies in the Bay–Delta. The research team is well–qualified to undertake this study. Reviewers had concerns that it was not clear what work had been already completed for Hg and MeHg in the current CALFED study. Furthermore, there is little discussion of how the results of the laboratory experiments will be "ground–truthed" to the sites of interest. While the investigators have cultured phytoplankton from previous work in the Bay–Delta, it appeared that the further aspects of the lab studies were decoupled from any further field comparisons. How do natural ligands in the study sites compare to those of the laboratory incubations? There is no mention of application of geochemical speciation models for both lab studies and**

**field applicability. Will spikes be pre−equilibrated with natural water (and ligands)? These omissions detract from a well−designed laboratory study and justify a rating less than “superior”.**

# Technical Synthesis Panel (Discussion) Review

## TSP Observations, Findings And Recommendations:

**Interactions of Mercury and Selenium in Bioaccumulation and Toxicity in San Francisco Bay Plankton**

**Research question: Can we model the uptake at the initial stages of the food chain?**

**Study is well justified, and proposes hypothesis−driven work. Researchers have extensive experience in this area of research. One external review had very little detail, and was not very useful. A main concern of the reviewers was that no effort was planned to ground truth the results of the study in the Bay−Delta system. Panelists would also like to see more on what controls aqueous speciation. The reviewers identified as a major concern that the phytoplankton would be exposed to Se and Hg sequentially, but not to both at the same time. Principal investigators should consider the use of stable isotopes to allow the direct addition of both.**

**Rating: above average**

# Technical Review #1

proposal title: Interactions of mercury and selenium in bioaccumulation and toxicity in San Francisco Bay plankton

## Review Form

### Goals

Are the goals, objectives and hypotheses clearly stated and internally consistent? Is the idea timely and important?

| | |
|---|---|
| **Comments** | **The author proposes to evaluate the interactions between selenium and mercury in estuarine phytoplankton and zooplankton. The null hypothesis to be tested is that the presence of one contaminant does not affect the bioaccumulation or toxicity of the other. The objectives of the program are clearly defined and presented. The idea of studying interactions between selenium and mercury is highly justified and very important not only for the region of San Francisco Bay for all other regions where Hg contamination has occurred.** |
| **Rating** | **very good** |

### Justification

Is the study justified relative to existing knowledge? Is a conceptual model clearly stated in the proposal and does it explain the underlying basis for the proposed work? Is the selection of research, pilot or demonstration project, or a full−scale implementation project justified?

| | |
|---|---|
| **Comments** | **There is a relatively abundant literature on Se−Hg interactions in laboratory animals and organisms that are positioned at higher levels of the trophic chain compared to phyto− and zooplankton. However, it is certain that little is known on Se−Hg interactions at this lower level of the food chain. There is a need** |

| | |
|---|---|
| | **to learn more about the bioaccumulation of both elements in plankton and to understand how the two elements interact at this level. The conceptual model is clearly stated in the proposal. However, the reader can sometimes get the impression that the author will repeat experimental work that has already be done on the bioaccumulation of mercury alone even if it is proposed to be done in comparison and combination with selenium.** |
| **Rating** | **very good** |

## Approach

Is the approach well designed and appropriate for meeting the objectives of the project? Is the approach feasible? Are results likely to add to the base of knowledge? Is the project likely to generate novel information, methodology, or approaches? Will the information ultimately be useful to decision makers?

| | |
|---|---|
| **Comments** | **The approach appears to be systematic and feasible although the author proposes to repeat a significant amount of experimental work on the separate uptake of mercury and selenium by organisms. It is not clearly mentioned how radioactivity introduced by tracers will be considered as a potential source of toxicity for algae and zooplankton? Details are missing on data treatment for bioaccumulation and toxicity p.13.** |
| **Rating** | **good** |

## Feasibility

Is the approach fully documented and technically feasible? What is the likelihood of success? Is the scale of the project consistent with the objectives and within the grasp of authors?

| | |
|---|---|
| **Comments** | **As mentioned before, the literature on selenium–mercury interactions is abundant. Many papers that are presented to justify the methodology and the scientific approach are from the author's group. Some** |

| | |
|---|---|
| | **papers are not cited accurately and I suggest to the author to re−examine some papers on Hg detoxification through the formation of mercuric sulfide and selenide, and those reporting field studies on mercury and selenium in fish muscle. To Consider: Why is Se added as selenite only? Can Se also exist in aquatic systems as Se(VI) and organic Se?**<br><br>**The scale of the project is consistent with most of the objectives and it will very likely be completed with success.** |
| **Rating** | **very good** |

## Monitoring

If applicable, is monitoring appropriately designed (pre−post comparisons; treatment−control comparisons)? Are there plans to interpret monitoring data or otherwise develop information?

| | |
|---|---|
| **Comments** | **not applicable** |
| **Rating** | **not applicable** |

## Products

Are products of value likely from the project? Are contributions to larger data management systems relevant and considered? Are interpretive (or interpretable) outcomes likely from the project?

| | |
|---|---|
| **Comments** | **A better knowledge on the interactions between the two elements will constitute a value and the results will help in the better management of aquatic systems. The possible protective action of selenium on the assimilation of mercury by living organisms can be used at a large scale for preventing Hg bioaccumulation or remediating contaminated areas.** |
| **Rating** | **very good** |

## Additional Comments

| | |
|---|---|
| **Comments** | **none** |

## Capabilities

What is the track record of authors in terms of past performance? Is the project team qualified to efficiently and effectively implement the proposed project? Do they have available the infrastructure and other aspects of support necessary to accomplish the project?

| | |
|---|---|
| **Comments** | **The author has a very impressive record of publications of good to excellent quality. He has a large experience and a recognized expertise in the topic. The infrastructure and equipments are available.** |
| **Rating** | **excellent** |

## Budget

Is the budget reasonable and adequate for the work proposed?

| | |
|---|---|
| **Comments** | **The budget seems reasonable and adequate for the work proposed.** |
| **Rating** | **very good** |

## Overall

Provide a brief explanation of your summary rating.

| | |
|---|---|
| **Comments** | **The proposal is of very good quality and the study on selenium–mercury interactions is highly justified for the proposed area and for the importance of the topic on a more global scale as well. Some minor points that could be considered to improve the proposal have been mentioned above. The author has an excellent record and it is expected that the results of the study will be of very high quality and will lead to excellent publications and to a better understanding of the proposed topic.** |

Technical Review #1

| | |
|---|---|
| **Rating** | **very good** |

# Technical Review #2

proposal title: Interactions of mercury and selenium in bioaccumulation and toxicity in San Francisco Bay plankton

## Review Form

### Goals

Are the goals, objectives and hypotheses clearly stated and internally consistent? Is the idea timely and important?

| | |
|---|---|
| **Comments** | **The goals and objectives are very clear. The diea is timely and important. Although directly relevant to the CALFED objectives, the results of this study will be more genral than those of most proposed studies (which are more focused on specific or narros problems).** |
| **Rating** | **excellent** |

### Justification

Is the study justified relative to existing knowledge? Is a conceptual model clearly stated in the proposal and does it explain the underlying basis for the proposed work? Is the selection of research, pilot or demonstration project, or a full−scale implementation project justified?

| | |
|---|---|
| **Comments** | **The authors provide a tremendous amount of information that justifies the study. The conceptual model is extremely clear and the study will justified clearly.**<br><br>**No. A pilot study does not seem to be a relevant option. A full scale implementation seems best.** |
| **Rating** | **not applicable** |

## Approach

Is the approach well designed and appropriate for meeting the objectives of the project? Is the approach feasible? Are results likely to add to the base of knowledge? Is the project likely to generate novel information, methodology, or approaches? Will the information ultimately be useful to decision makers?

| | |
|---|---|
| **Comments** | **The design is extremely good and will meet the objectives. The propopsed work is linked to successful, published work by the authors.**<br><br>**The study will definitely generate new knowledge of local and global relevance.** |
| **Rating** | **excellent** |

## Feasibility

Is the approach fully documented and technically feasible? What is the likelihood of success? Is the scale of the project consistent with the objectives and within the grasp of authors?

| | |
|---|---|
| **Comments** | **The work is technically difficult but the past publications of the authors demonstrate their abilities to do such studies successfully.** |
| **Rating** | **excellent** |

## Monitoring

If applicable, is monitoring appropriately designed (pre−post comparisons; treatment−control comparisons)? Are there plans to interpret monitoring data or otherwise develop information?

| | |
|---|---|
| **Comments** | |
| **Rating** | **not applicable** |

## Products

Are products of value likely from the project? Are contributions to larger data management systems relevant and considered? Are interpretive (or interpretable) outcomes likely from the

project?

| | |
|---|---|
| **Comments** | **Valuable products will be produced and the information will contribute to the data base needed to manage the area.** |
| **Rating** | **very good** |

## Additional Comments

| |
|---|
| **Comments** |

## Capabilities

What is the track record of authors in terms of past performance? Is the project team qualified to efficiently and effectively implement the proposed project? Do they have available the infrastructure and other aspects of support necessary to accomplish the project?

| | |
|---|---|
| **Comments** | **Fisher has an extraordinary published track record in the area of the proposed work. The team is weill qualified to do this job.** |
| **Rating** | **excellent** |

## Budget

Is the budget reasonable and adequate for the work proposed?

| | |
|---|---|
| **Comments** | **The budget seems appropriate but I personally have little knowledge of the costs for this type of research.** |
| **Rating** | **very good** |

## Overall

Provide a brief explanation of your summary rating.

| | |
|---|---|
| **Comments** | **The scientific value of this work is excellent. The local value is also very high. Dr. Fisher's published** |

| | |
|---|---|
| | **work is extraordinary so, extraploting from the past, the data from this study will also be extraordinary.** |
| **Rating** | **excellent** |